5.9 Geology and Soils

5.9 GEOLOGY AND SOILS

This section evaluates the geologic and seismic conditions within the City of Seal Beach and evaluates the potential for geologic hazard impacts associated with implementation of the proposed project. Information in this section is based on the following documentation:

- *Preliminary Geotechnical Evaluation for Proposed Residential Development* (Preliminary Geotechnical Evaluation), prepared by GeoTek, Inc., dated September 12, 2005 (refer to Appendix 11.8, *Geology, Soils, and Seismicity Data*);
- *Geology, Soils, and Seismicity Report in Support of DWP Specific Plan Amendment EIR, Seal Beach California* (Geology Report), prepared by D. Scott Magorien, C.E.G. Consulting Engineering Geologist, dated June 27, 2011 (refer to Appendix 11.8, *Geology, Soils, and Seismicity Data*);
- *City of Seal Beach General Plan* (December 2003); and
- *City of Seal Beach Municipal Code.*

5.9.1 EXISTING SETTING

GEOLOGIC SETTING

The project site is situated within a coastal lowland area referred to as the Alamitos Gap (Gap), a portion of the Orange County Coastal Plain. The creation of the Gap began in Late Pleistocene time (approximately 60,000 years before present) and continued until the end of the last glacial period, approximately 15,000 years before present. The combination of a lowered sea level and accelerated stream erosion produced the ancestral San Gabriel River valley, which is at most approximately 100 feet deep and a mile wide. At the end of the glacial period the sea level began to rise, and the ancestral river began backfilling the valley with coastal alluvial deposits. Much of what is known about the subsurface conditions and late Pleistocene erosion and subsequent Holocene-age (0 to 11,000 years before present) sediment deposition in the region has been reported by the United States Geological Survey, California Geological Survey, California Department of Water Resources, Orange County Water District, and a number of site-specific investigations performed by various consulting firms for local agencies.

The Gap is underlain at shallow depths by Holocene sediments consisting of ancient river and flood plain (i.e., fluvial and alluvial) deposits associated with the San Gabriel River, and near-shore estuarine, delta, and lagoonal (i.e., paralic) deposits. These sediments consist of unconsolidated sand, gravel, silt, and clay. Erosional remnants of what is interpreted by the California Geological Survey to be older, more consolidated paralic deposits of late to middle Pleistocene-age, underlies the man-modified, low-lying coastal bluff that was situated along the coastline between Anaheim Bay and the modern San Gabriel River.

The project site, which is underlain by both Holocene and late to middle Pleistocene paralic deposits, is mantled by approximately three feet of artificial fill soils that were imported to the site following the demolition of the former Los Angeles Gas & Electric power plant. Between 1925 and 1967, the main power plant existed in the south central portion of the project site, along with appurtenant structures within the northern half of the site.

According to State of California Division of Oil, Gas, and Geothermal Resources District 1, Map 132 (dated August 14, 2007), the project site is not situated within an active or historic oil or gas field. The nearest active oil fields are the Seal Beach and Wilmington fields, which are located approximately one mile north and south of the project site, respectively. The closest active oil wells lie within the Hellman Ranch field that is located approximately 1.1 miles to the north, and is associated with what is referred to as the Newport-Inglewood Structural Trend. A number of other significant oil fields are located along the Newport-Inglewood Trend.

SITE CONDITIONS

Historically, before 1868, much of the central portion of the project site was represented by the northwestern-most tip of a low-lying coastal bluff. The low bluff was bounded on the north and west by Holocene age (0 to 11,000 year old) alluvial/fluvial (i.e. stream lain) deposits, and on the south by both fluvial and near shore marine sediments. During this time, the outlet for the San Gabriel River was located approximately 2,800 feet further up the coast. Between 1868 and 1931, the San Gabriel River had migrated southward and cut a new channel to the ocean with its outlet adjacent to the western boundary of the project site.

During the late 1920s, the Los Angeles County Flood Control District (LACFCD) had improved the lower reach of the San Gabriel River by straightening and widening the channel to a point approximately 4,000 feet northerly of the outlet of the San Gabriel River, which was located directly adjacent to the former Los Angeles Gas & Electric power plant. In 1931 the LACFCD prepared design plans to improve the remaining southern 4,000 feet of the San Gabriel River to its outlet with the Pacific Ocean. These plans called for deepening and widening of the natural river channel, constructing a rock bulkhead along the majority of the channel section adjacent to the project site, and placing rock facing along a 100-foot-long section of the channel adjacent to the water intake structure for the plant. According to the design plans, with the exception of approximately 200 feet, there was an underground bulkhead along the edge of the channel directly adjacent to the power plant. This bulkhead extended to a depth of approximately (-)30 feet mean sea level (msl) and was bordered on its western side by a 25-foot-wide, one- to 10-foot-high sloping section of protective rip-rap. The 1931 design plans also indicate that the 200-foot-long section along the edge of the channel steel sheet piling had been driven by Los Angeles Gas & Electric to a depth of approximately (-)22 feet msl. Based on a review of aerial photographs taken on May 17, 1940, it appears that LACFCD's channel improvements had been implemented.

By 1952, the Los Angeles Gas & Electric site, which was now owned by the Los Angeles Department of Water and Power (DWP), was occupied by the main plant and what appears to be a nearby cooling tower array, a row of buildings along the western edge of 1st Street, and two large above-ground fuel storage tanks in the northwest and northeast corners of the project site. A review of aerial photographs taken on June 20, 1966 depicts similar conditions, with the exception of some of the buildings along 1st Street, which have been removed.

During the late 1950s to early 1960s, the US Army Corp of Engineers (USACE) redesigned and constructed a new levee section along each side of the outlet for the San Gabriel River. According to USACE's as-built plans (dated May 8, 1963) the new levee section adjacent to the project site involved increasing the size and extent of former levees constructed by the LACFCD. Refer to Figure 1 of the Geology Report within Appendix 11.8 for a typical profile showing the original levee circa 1931 and new levee. It is unknown if the earlier Los Angeles Gas & Electric bulkheads and/or the sheet piling were left in place or removed during the reconstruction.

By 1966, the Los Angeles Gas & Electric plant was decommissioned and it was demolished in 1967. No geotechnical or design information regarding the original design of the plant or the demolition and restoration of the property is currently available. However, during the exploratory Cone Penetration Test work conducted as part of the Geology Report, two of the Cone Penetration Tests (CPT-2A and CPT-2B) were situated within the footprint of the former plant and met with refusal at eight feet below ground surface. Based on the inability of the Cone Penetration Tests to penetrate any further, it is presumed that there may be some portions of the foundation or other underground structures still remaining of the former plant in the proposed park/open space area.

Currently, the project site is essentially featureless with ground surface elevations ranging from approximately 10 feet above msl along the western margin where it abuts the levee of the San Gabriel River, to a high of approximately 18 feet above msl in the south-central portion of the project site. This subdued topographic high corresponds to the former natural, low-lying bluff that occupied the south central portion of the project site.

GEOLOGIC MATERIALS

The geologic materials that underlie the project site include artificial fill soils, deposits associated with the San Gabriel River, and near-shore estuarine, delta, and lagoonal (i.e., paralic) deposits of Holocene and mid to late Pleistocene age.

Artificial fill

Artificial fill soils reportedly form a three-foot-thick veneer across the entire project site. In the vicinity of the levee, varying thicknesses of artificial fill occupy the area between the bike trail and the San Gabriel River right-of way, which appears to coincide with an existing chain link fence. Given the past history of the project site, there is the potential to find other areas underlain by significant amounts of fill soils or other construction debris. Based on observations during drilling of the exploratory borings and results of the Cone Penetration Test surveys conducted as part of the Geology Report, artificial fill soils that occur within the project site are loose, dry, porous, and may contain varying amounts of inorganic debris/trash. Where these "non-engineered" types of soils are encountered, they are highly erodible and expected to be compressible, and therefore subject to consolidation. Buildings, foundations, and/or structural elements could experience moderate to significant distress resulting from these soils.

Holocene Age Paralic Estuarine Deposits

These unconsolidated sediments have been deposited in a near-shore estuarine and delta-like environmental setting, and include sediments deposited by intermittent stream flows and periods of severe flooding during the Holocene (last 11,000 years). Given the proximity to the ocean, these deposits are also intermixed with near shore marine deposits, and may likely contain salt and other evaporates. Based on information obtained from the exploratory borings and Cone Penetration Tests, these sediments consist of layers and lenses of sand, silt, clay, and mixtures thereof, and were encountered to depths of up to approximately 55 feet below ground surface. Some of the finer grained silts and clays contain scattered remains of small plant fragments and other organic detritus. These soils are subject to liquefaction, lateral spread, seismically-induced landsliding, and are corrosive to ferrous metals.

Late to Middle Pleistocene Age Paralic Deposits

Based on geologic mapping, these older, soil-like deposits form part of a relatively thick, blanket-like deposit that underlies the nearby Landing Hill topographic high, a portion of the Naval Weapons Station, and the former low-lying coastal bluff that occupied the areas between Anaheim Bay and the San Gabriel River. Much of the former Los Angeles Gas & Electric power plant was situated atop the southeastern-most exposure of these sediments. These sediments were encountered in several exploratory borings and Cone Penetration Tests within the project site, including USACE's 1960 boring (TH-69), Preliminary Geotechnical Evaluation exploratory boring (B-3), and the recent Cone Penetration Tests (CPT-2 and CPT-3) that were performed as part of the Geology Report. The approximate subaerial extent of these sediments is depicted on Figure 1 of the Geology Report within Appendix 11.8. Given the relatively dense nature of these deposits, there are no significant constraints associated with liquefaction or lateral spread. However, where these deposits lay astride the San Gabriel River the likelihood for seismically-induced landsliding cannot be precluded.

GROUNDWATER

Shallow groundwater beneath the project site is saline due to its interconnection with the Pacific Ocean. Thus, it is considered a non potable water source. Based on historic and recent groundwater level data, the elevation of the groundwater table beneath the project site varies from approximately one to five feet above msl, and mainly is a function of tidal influence from the Pacific Ocean and the water level in the nearby San Gabriel River. There is no evidence of past or present groundwater use in the project area. No evidence of springs or seeps has been noted within or adjacent to the project site.

MINERAL RESOURCES

There are no economic metallic or non-metallic ore deposits within or in the vicinity of the project area. However, the active Seal Beach and Wilmington oil fields are located approximately one mile north and south of the site, respectively. According to the State of California Division of Oil, Gas, and Geothermal Resources District 1, Map 132 (dated August 14, 2007), the closest existing or abandoned oil wells are located within approximately one-half mile of the project site. Based on the General Plan, the project site is not known to contain mines, mineral deposits, or other mineral resources.

GEOLOGIC HAZARDS AND GEOTECHNICAL CONSTRAINTS

There are potential geologic hazards and geotechnical constraints present in the project area. Seismic hazards within the project area are seismically-induced ground shaking, landsliding and settlement, liquefaction, lateral spreading, and tsunami run-up. Non seismic-related geologic hazards within the project area include the presence of corrosive soils and soils subject to sloughing and caving during excavation. There is currently no evidence that suggests the presence of soils containing collapsible, organic peat deposits, or expansive soils on the project site. The following discussion addresses the geologic hazards and geotechnical constraints.

Faulting and Seismicity

The project area is situated within a seismically active area of southern California referred to as the Los Angeles Basin. Hazards associated with earthquakes include primary seismic hazards, such as ground shaking and surface rupture, and secondary seismic hazards, such as liquefaction, seismically-induced settlement, landsliding, tsunamis, and seiches.

Seismically-Induced Ground Shaking

According to the California Geological Survey, a fault is defined as a fracture in the crust of the earth along which rocks on one side have moved relative to those on the other side. Most faults are the result of repeated displacements over a long period of time. An inactive fault is a fault that has not experienced earthquake activity within the last three million years. In comparison, an active fault is one that has experienced earthquake activity in the past 11,000 years. A fault that has moved within the last two to three million years, but has not been proven by direct evidence to have moved within the last 11,000 years, is considered potentially active. No active or potentially active faults are located within or towards the project area.

The Alquist-Priolo Earthquake Fault Zoning Act, Public Resources Code Sections 2621-2624, Division 2, Chapter 7.5 regulates development near active faults in order to mitigate the hazard of surface fault-rupture. Under the Act, the State Geologist is required to delineate "special study zones" along known active faults in California. The Act also requires that, prior to approval of a project, a geologic study be conducted to define and delineate any hazards from surface rupture. A geologist registered by the State of California, within or retained by the lead agency for the project, must prepare this geologic report. A 50-foot setback from any known trace of an active fault is required. The project area is not currently known to be located within an Alquist-Priolo Earthquake Fault Zone, according to the California Geological Survey. The closest Earthquake Fault Zone to the project site is the Seal Beach segment of the Newport Inglewood fault zone, located approximately one mile to the north of the project site.

The Modified Mercalli Intensity (MMI) scale was developed in 1931 and measures the intensity of an earthquake's effects in a given locality, and is perhaps much more meaningful to the layman because it is based on actual observations of earthquake effects at specific places. On the MMI scale, values range from I to XII. The most commonly used adaptation covers the range of intensity from the conditions of: "I – not felt except by very few, favorably situated", to "XII – damage total, lines of sight disturbed, and objects thrown into the air." While an earthquake has only one magnitude, it can have many intensities, which decrease with distance from the epicenter. Ground motions, on the other hand, are often measured in percentage of gravity (percent g), where g is equal to 32 feet per second per second (980 cm/sec^2) on the earth.

The project area, like most of southern California, is part of a seismically active region. The project site can be expected to experience ground shaking accompanying earthquakes on nearby faults. However, the intensity of ground shaking would depend upon the magnitude of the earthquake, the distance to the epicenter, and the geology of the area between the epicenter and the property.

Table 5.9-1, *Active Faults*, provides a list of active faults considered capable of producing strong ground motion at the project site, their closest distances to the site, and the maximum expected earthquake along each fault. Also presented are generalized evaluations of maximum ground shaking that could occur at the project site for the maximum earthquakes, and generalized predictions of the likelihood of such events occurring.

Table 5.9-1
Active Faults

Fault	Miles from Project Site	Maximum Magnitude (M)	Expected Level of Ground Shaking	Likelihood
Newport-Inglewood (Seal Beach)	1.1	7.1	High	High
Palos Verdes (Offshore)	3.0	7.3	High	High
Puente Hills Blind Thrust[1]	4.5	7.1	High	High
San Joaquin Hills Blind Thrust[1]	8.0	6.6	High	Moderate
Whittier-Elsinore	16.0	6.8	Moderate	High
Santa Monica	27.5	6.6	Moderate	Moderate
Malibu Coast	29.5	6.7	Moderate	Moderate
Hollywood-Raymond	25.7	6.4 to 6.5	Moderate	High
Sierra Madre-Cucamonga	28.5	6.9 to 7.2	Moderate	High
San Jacinto (Anza)	47.5	7.2	Moderate	High
San Andreas (Mojave)	47.8	7.5	Moderate	High
Santa Susana	60	6.7	Low	Moderate

Notes:
1. Fault is termed "blind thrust fault" because it has no surface exposure. The closest distance from the project site is based on a projection of the rupture area along the subsurface trace of the fault.

Source: D. Scott Magorien, C.E.G., *Geology, Soils, and Seismicity* (Geology Report), June 27, 2011.

As indicated in Table 5.9-1, the greatest amount of ground shaking at the project site would be expected to accompany large earthquakes on the Newport-Inglewood and Palos Verdes faults, and the Puente Hills and San Joaquin Hills Blind Thrust faults.

Liquefaction

Seismic ground shaking of relatively loose, granular soils that are saturated or submerged can cause the soils to liquefy and temporarily behave as a dense fluid. Liquefaction is caused by a sudden temporary increase in pore water pressure due to seismic densification or other displacement of submerged granular soils. Liquefaction more often occurs in earthquake-prone areas underlain by young (i.e. Holocene age) alluvium where the groundwater table is higher than 50 feet below ground surface. The project site is designated as being within a zone having the potential for earthquake-induced liquefaction.

The California Geological Survey has designated certain areas within California as potential liquefaction hazard zones. As shown on the State of California's Seismic Hazard Zone Map for the Seal Beach 7.5-foot Quadrangle, the project site lies within an area of high liquefaction potential. This assessment is further validated by the results of the subsurface geotechnical studies performed for the project site, further described below.

According to the Preliminary Geotechnical Evaluation, the most significant geotechnical considerations are the potential for earthquake-induced soil settlement, the presence of relatively loose fill materials, and a relatively shallow groundwater level. Limited Standard Penetration Test data conducted as part of the Preliminary Geotechnical Evaluation indicate that the sand and silt layers encountered in borings B-1 and B-4 at various depths between the existing ground surface and 56 feet below ground surface are highly susceptible to liquefaction during strong ground motion from nearby seismic sources. The extent of the potentially liquefiable layers provided in the Preliminary Geotechnical Evaluation is in accordance with the findings from the subsurface investigation conducted as part of the Geology Report prepared for the project site. Limited Standard Penetration Test and Cone Penetration Test data show that the sand and silt layers at various depths between the existing ground surface and 76 feet below ground surface are susceptible to liquefaction.

The most current ground motion information provided by the United States Geological Survey (2008) and the current design guidelines provided in the 2010 California Building Code (CBC) were reviewed to further determine the liquefaction potential at the project site. The earthquake parameters used in the Preliminary Geotechnical Evaluation were based on the Maximum Credible Earthquake on the Newport Inglewood fault zone with a magnitude of M6.9, and a peak ground acceleration of 0.58g. The Preliminary Geotechnical Evaluation scaled the ground acceleration with respect to a M7.5 earthquake in order to apply the scaled peak ground acceleration to the liquefaction susceptibility analyses. A peak ground acceleration of 0.47g was utilized in the liquefaction evaluation. The current seismic design guidelines as presented in American Society of Civil Engineers (ASCE) 7-05 (ASCE 2006) requires the use of peak ground acceleration from the Maximum Credible Earthquake with a two percent probability of exceedance in 50 years as the design ground motion for the evaluation of triggering liquefaction. However, the 2010 CBC permits estimation of peak ground acceleration as $2/5*S_{DS}$, where S_{DS} is estimated in accordance with Section 1613.5.4 of 2010 CBC. Based on the 2010 CBC, the level of ground motion at the project site is approximately 0.46g. This value of 0.46g is in agreement with the Preliminary Geotechnical Evaluation.

The liquefaction susceptible layers were identified to be between existing ground surface and 58 feet below ground surface, based on the Standard Penetration Test data obtained during drilling of the Preliminary Geotechnical Evaluation borings. The Geology Report indicates that even deeper layers, between 58 feet below ground surface and 75 feet below ground surface, may be susceptible to liquefaction, based on Standard Penetration Test data from the borings, and the resistance measured in the Cone Penetration Tests; refer to Appendix 11.8.

The liquefaction potential and associated settlement of soils at the project site were further evaluated as part of the Geology Report. The evaluation used the Standard Penetration Test results, and equivalent Standard Penetration Test values from blow counts using a California Modified ring sampler, in accordance with the methodology outlined by Idriss and Boulanger (2008) using the groundwater elevation provided in the Preliminary Geotechnical Evaluation evaluation (i.e., nine feet below ground surface). Refer to Appendix 11.8 for the liquefaction analyses performed for the estimated seismically-induced settlement (assuming an M7.1 earthquake with a peak ground acceleration of 0.46g).

The Preliminary Geotechnical Evaluation anticipated that liquefied soils may experience post-liquefaction settlements of four to eight inches. The liquefaction analysis conducted as part of the Geology Report indicated that the estimated settlements due to liquefaction of the saturated Holocene age soils at the project site are on the order of approximately 6.2 to 6.4 inches. In addition, estimated settlements due to liquefaction using the empirical procedures may be within 50 percent of the estimated values. As such, the estimated settlements associated with the borings should be considered within the range of three to nine inches, which is in general agreement with the Preliminary Geotechnical Evaluation estimation.

Seismically-induced settlement was also estimated using the Cone Penetration Test data. Soil layers that possessed factors of safety less than 1.3 are expected to undergo volumetric strain, and as a result, settle due to liquefaction; refer to Appendix 11.8.

Lateral Spreading

Lateral spreading involves the dislocation of the near surface soils generally along a near-surface liquefiable layer. In many cases, this phenomenon of shallow landsliding occurs on relatively flat or gently sloping ground adjacent to a "free face," such as a river embankment. Given the "weak" nature of the near surface, fine-grained sediments, shallow groundwater, liquefaction-prone soils, and the adjacent San Gabriel River, there is a high potential for lateral spread at the project site during a major earthquake in the area.

The Preliminary Geotechnical Evaluation addressed the potential for lateral spread within the project site. Based on the subsurface data obtained during the field investigation, the Preliminary Geotechnical Evaluation performed a preliminary estimate of liquefaction-induced lateral spreading that could occur toward the San Gabriel River. The Preliminary Geotechnical Evaluation utilized Youd, Hansen, and Bartlett's Procedure (2002) to estimate the amount of lateral spreading within the project site. This procedure uses empirical equations, based on case history data. The Preliminary Geotechnical Evaluation estimated that as much as two to four feet of lateral spreading could occur at a point located approximately 100 feet easterly from the San Gabriel River, as a result of a design magnitude seismic event. However, in order for this procedure to produce reliable displacement predictions (i.e., plus or minus a factor of two), the input parameters must be within the ranges that are set forth in the Youd (et al., 2002) research paper. However, the input parameters used by the Preliminary Geotechnical Evaluation do not fall within the range prescribed by Youd (et al., 2002). Consequently, as part of the Geology Report, lateral spreading analyses were performed using the same procedures as the Preliminary Geotechnical Evaluation based on the information obtained during the 2011 subsurface investigation. The Geology Report estimated considerably more lateral spreading could potentially occur at the project site. The estimated lateral spreading is on the order of 16 feet. It is believed that the major difference between the results of the two analyses is because of one of the input parameters, namely the fines content of subsurface native materials included in the cumulative thickness of saturated granular layers with (N1)60 values less than 15, used in the equations.

The subsurface data provided in the Preliminary Geotechnical Evaluation boring B-4 indicate that fines content of the materials in the saturated layers with (N1)60 values less than 15 is approximately 60 percent whereas, in the Geology Report, a value of 22.8 percent was used based on the arithmetic mean of the data obtained from the laboratory testing.

Seismically-Induced Landsliding

The potential for seismically-induced landsliding along the embankment/levee of the San Gabriel River is considered moderate to high. Analytical procedures for estimating the potential lateral deformations have been developed for both sloping ground and a free face model. However, in case of a steep embankment section, such as a channel, a more applicable evaluation of lateral movement would be a seismic slope deformation analysis.

Seismic stability of the channel embankment was evaluated using the Bray and Travasarou (2007) method for estimating earthquake-induced deviatoric slope displacements using the seismic design parameters presented in the Geology Report. In this method, pseudo-static slope stability analyses were performed to obtain the yield coefficient (k_y) of each sliding mass by applying a horizontal force that develops a Factor of Safety (FS) equal to 1.0. The initial fundamental site period (T_s) and ground motions spectral accelerations at a degraded period equal to $1.5T_s$ were then used to estimate the range of probabilistic slope displacements (mean ± 1 standard deviation).

The seismically-induced liquefaction analyses identified several layers as potentially liquefiable. A relationship between residual shear strength and corrected "clean sand" SPT blowcount $(N_1)_{60}$, as published by Seed and Harder (1990), was utilized to estimate the post liquefaction residual shear strength values for the potentially liquefiable layers. These values were used in pseudo-static slope stability analyses to obtain the yield acceleration.

Based upon the procedures outlined in Bray and Travasarou (2007), it was determined that the potential for seismically-induced landsliding along the levee of the adjacent San Gabriel River is considered to be moderate to high. Potential seismic slope deformation under existing conditions was estimated to range from one to four feet. Calculations for seismically-induced slope deformation are presented in <u>Appendix 11.8</u>.

Seismically-Induced Soil Settlement

Strong ground shaking can cause settlement by allowing sediment particles to become more tightly packed, thereby reducing pore space. Unconsolidated, loosely packed alluvial deposits are especially susceptible to this phenomenon. Poorly compacted artificial fills may also experience seismically-induced settlement. Based on the subsurface data obtained from the exploratory borings drilled for the Preliminary Geotechnical Evaluation, and the two borings performed for the Geology Report, the Holocene age alluvial soils are, for the most part, prone to seismically-induced settlement. In addition, portions of the project site that are mantled with non-engineered (i.e. loose) fill soils may likely be subject to seismically-induced settlement and/or development of ground cracking.

Seismically-Induced Ground Settlement of Dry Sands

Seismically-induced settlement of dry sands typically occurs with loose, relatively clean (i.e., with little or no fines) sands that are situated above the groundwater table. An analysis was performed according to criteria outlined by Tokimatsu and Seed (1987). The dynamic settlement of dry sands was evaluated using the Standard Penetration Test data obtained during the subsurface investigation. The same peak ground acceleration and moment magnitude values used in the liquefaction analyses were used in this analysis. The results of this evaluation indicate that a maximum estimated settlement of the dry sandy soils due to the design seismic event at the project site is on the order of 1.75 inches; refer to Appendix 11.8.

Ground Lurching

Lurching is a phenomenon in which loose to poorly consolidated deposits move laterally as a response to strong ground shaking during an earthquake. Lurching is typically associated with soil deposits on or adjacent to steep slopes. Certain soils have been observed to move in a wave-like manner in response to intense seismic ground shaking, forming ridges or cracks on the ground surface. Areas underlain by thick accumulations of alluvium appear to be more susceptible to ground lurching than bedrock. Under strong seismic ground motion conditions, lurching can be expected within loose, cohesionless soils, or in clay-rich soils with high moisture content. Generally, only lightly-loaded structures such as pavement, fences, pipelines, and walkways are damaged by ground lurching; more heavily loaded structures appear to resist such deformation. Ground lurching may occur within the project site where deposits of loose alluvium and/or artificial fill soils exist adjacent to the San Gabriel River levee.

Flooding/Tsunami Run-Up

Flood hazards include storm-induced flooding, and those caused by earthquakes, namely tsunami and dam failure. According to the latest Flood Insurance Rate Map (FIRM) prepared by the Federal Emergency Management Agency (FEMA), the project area does not lie within either a 100-year or 500-year flood area, or within a dam inundation area. The FIRM delineates the project site as being in "Zone X," which is defined as an area of 0.2 percent annual chance of flood: area of one percent chance flood with average depths of less than one foot; refer to Section 5.11, *Hydrology and Water Quality*, for a discussion of potential flood hazards associated with the project site.

The greatest flooding hazard to the project site is associated with tsunami inundation. A tsunami is a seismic sea-wave caused by sea-bottom deformations that are typically associated with a submarine earthquake.

The California Emergency Management Agency, in cooperation with California Geological Survey, produced a Tsunami Inundation Map for the Seal Beach 7.5" Quadrangle (dated March 15, 2009) that depicts the project site and surrounding neighborhood lying within a tsunami inundation area. As addressed in the latest edition of FEMA's Coastal Construction Manual, a tsunami with a 90 percent probability of not being exceeded in 50 years has the potential run-up elevation at the project site of up to 15 feet msl; refer to Section 5.11, *Hydrology and Water Quality*, for a discussion of potential impacts associated with tsunamis.

Seiching

Seiching involves an enclosed body of water oscillating due to ground shaking, usually following an earthquake. Lakes and water towers are typical bodies of water affected by seiching. Given that there are no large, enclosed open bodies of water or reservoirs upgradient of the project area, the likelihood of an earthquake-induced seiche is considered remote; refer to Section 5.11, *Hydrology and Water Quality*, for a discussion of potential impacts associated with seiching.

Other Geological Hazards

Shallow Groundwater

Depth to groundwater under the project site is known to vary between approximately five to 11 feet below ground surface. Saturated soils and caving conditions would likely be encountered during remedial grading associated with removal and re-compaction of soils within several feet above, or at any depth below the groundwater table.

Corrosive Soils

Corrosive soils contain chemical constituents that can react with construction materials, such as concrete and ferrous metals, that may cause damage to foundations and buried pipelines. One such constituent is water-soluble sulfate which, if in a high enough concentration, can react with and damage concrete. Electrical resistivity and pH level are indicators of the soil's tendency to corrode ferrous metals. According to limited laboratory testing done as part of the Preliminary Geotechnical Evaluation, near surface soils have a relatively high pH value (8.2), and low resistivity (less than 1000 ohm-cm), indicating these soils are considered highly corrosive when in contact with ferrous metals. Water soluble sulfate content of 0.039 percent by weight was found within a soil sample, which is an indication of negligible sulfate exposure.

Expansive Soils

Expansive soils are clay-rich soils that can undergo a significant increase in volume with increased water content and a significant decrease in volume with a decrease in water content. Significant changes in moisture content within moderately to highly expansive soil can produce cracking differential heave, and other adverse impacts to structures constructed on such soils. Based on the results of the laboratory test performed as part of the Preliminary Geotechnical Evaluation, the soils encountered in the borings are anticipated to exhibit "low to medium" expansion potential and, therefore, the potential for expansive soils to impact new development is considered low.

Subsidence

The extraction of groundwater or oil from sedimentary source rocks can cause the permanent collapse of pore space that was previously occupied by the removed fluid. The compaction of subsurface sediments resulting from fluid withdrawal can and has caused the ground surface overlying fluid reservoirs to subside. If sufficiently great, the subsidence can cause significant damage to nearby engineered structures. The project site is not situated within an active or historic oil or gas field. The nearest major oil producing areas in the vicinity of the project site are the Seal Beach and Wilmington fields located approximately one mile to the north and south, respectively.

During the major oil and gas production years between 1928 and 1970, oil withdrawals within the Wilmington field produced approximately 1.5 feet of land subsidence in the vicinity of the site. However, beginning in the late 1950s, water injection into various wells was employed to arrest the subsidence, which produced approximately 0.1 feet of rebound (recovered elevation) at the project site, as measured during the period 1966 to 1970. There is no indication that the project site has experienced any significant subsidence or rebound since 1970. Further, there has been no measurable land subsidence documented within the nearby Seal Beach/Hellman Ranch oil field during the last 60 years.

Soil Erosion

Soil erosion is most prevalent in unconsolidated alluvium and surficial soils, which are prone to downcutting, sheetflow, and slumping and bank failure during and after heavy rainstorms. Strong wind forces can also produce varying amounts of soil erosion of unconsolidated surficial soils. However, long-term shoreline erosion can be caused by a number of factors, such as rising sea levels, reduced sediment supply to the coast, dredging of the nearby San Gabriel River and increased incidence of intensity of storms.

The project site is relatively flat and does not possess site conditions necessarily conducive to soil erosion. However, given the inherent uncertainties regarding long-term shoreline erosion, there is the potential for long-term shoreline erosion within the project area to occur.

Sloughing or Caving of Excavations

Unconsolidated/noncohesive artificial fill, as well as saturated paralic soils, occur within the project site. If unsupported, these soils could be subject to sloughing and caving, creating a short-term hazard to construction workers and equipment.

Prime Farmland

Based on a review of historic aerial photographs dating back to 1927, there is no indication that the project site was used for farming or other agricultural purposes.

5.9.2 REGULATORY SETTING

FEDERAL

The purpose of the Federal Soil Protection Act is to protect or restore the functions of the soil on a permanent sustainable basis. Protection and restoration activities include prevention of harmful soil changes, rehabilitation of the soil of contaminated sites and of water contaminated by such sites, and precautions against negative soil impacts. If impacts are made on the soil, disruptions of its natural functions as an archive of natural and cultural history should be avoided, as far as practicable. In addition, the requirements of the Federal Water Pollution Control Act (also referred to as the Clean Water Act [CWA]) through the National Pollution Discharge Elimination System (NPDES) provide guidance for protection of geologic and soil resources.

STATE

California Building Code

California building standards are published in the California Code of Regulations, Title 24, known as the CBC. The 2010 CBC applies to all applications for building permits. The 2010 CBC contains administrative regulations for the California Building Standards Commission and for all State agencies that implement or enforce building standards. Local agencies must ensure that development complies with the guidelines contained in the 2010 CBC. Cities and counties have the ability to adopt additional building standards beyond the 2010 CBC.

LOCAL

Seal Beach General Plan Safety Element

The Safety Element addresses a variety of hazards that could affect the City, including geologic hazards. Potential risks to residents and the local environment associated with geologic hazards such as ground shaking, liquefaction, soil failure, tsunamis, and seiches, are considered. The Safety Element provides background information related to each issue, and identifies policies pertaining to the potential geologic hazards that could occur within the City. The following are Safety Element policies related to geologic issues that may be applicable to the proposed project. Refer to Section 5.10, *Hazards and Hazardous Materials* for policies regarding hazardous conditions within the City, and Section 5.11, *Hydrology and Water Quality* for policies pertaining to drainage and water quality.

- Require a soils and geology report to be prepared and filed for all development projects as specified in the City's Municipal Code. (3A)
- Require geological surveys to be prepared after onsite borings or subsurface explorations at the time subdivisions are submitted to the City for approval. (3B)
- Require supervision by a state licensed soils engineer for grading operations which require a grading permit. (3C)
- Maintain and enforce protection measures which address control of runoff and erosion by vegetation management, control of access, and site planning for new development and major remodels, including directing runoff to the street and compliance with setbacks. (3D)
- Restrict development projects that will cause hazardous geologic conditions or that will expose existing developments to an unacceptable level of risk until the causative factors are mitigated. (3E)
- Require the use of drought-resistant vegetation with deep root systems where appropriate for safety reasons in new development projects to reduce the potential for over irrigation. Encourage the use of drought-resistant vegetation throughout the City through public education efforts. (3I)
- Determine the liquefaction potential of a site prior to development and require that specific measures be taken, as necessary, to reduce damage in an earthquake. (3N)

Seal Beach Municipal Code

Title 9: Public Property, Public Works, and Building Regulations

City of Seal Beach Municipal Code (Municipal Code) Title 9: Public Property, Public Works, and Building Regulations, establishes grading and building requirements for the City. Chapter 9.50, Grading, addresses grading activities, including activities requiring a grading permit. Specifically, section 9.50.015, Grading Permit Requirement, states that a grading permit is required for the following activities:

- Grading or land disturbing or land filling on existing grade that is prepatory to grading;
- Clearing, brushing and grubbing;
- Construction of pavement surfacing in excess of 2,499 square feet on existing grade for the purpose of a road or parking lot; and
- Alteration of an existing watercourse, channel or revetment by means of excavation, fill placement, or installation of rock protection or structural improvements.

Section 9.50.020, Approval or Denial of Grading Permit, requires that all grading permit applications include plans and specifications, as well as supporting data consisting of soil engineering and engineering geology reports, unless waived by the City Engineer.

Chapter 9.60, Building Code, contains the Building and Safety Code of the City of Seal Beach. The Building and Safety Code adopts several individual codes, including the California Building Code, 2010 Edition, Incorporating the 2009 "International Building Code" including Appendix F, I and J, by reference. Construction, removal, alteration, moving, or repair of any work or equipment on any premises within the City, with some exceptions, are required to comply with the provisions of the Building and Safety Code.

Section 9.60.015, Engineering Data, requires computations, related diagrams and other engineering data sufficient to show the correctness of the structural, electrical, mechanical, plumbing, and other plans be submitted when required by the building official.

Section 9.60.020, Building Permit Requirement, requires a separate building permit for each building or structure to be obtained from the building official prior to a person erecting, constructing, enlarging, altering, repairing, moving, improving, removing, converting or demolishing, equipping, using, occupying, or maintaining any building or structure or cause or permit the same to occur.

Building Code Subsection 313.13, Corrosive Soils, states that all earth within the City is corrosive unless proven to the satisfaction of the building official the specific earth is not corrosive to plumping, piping, fittings, fixtures and/or equipment for installation or contact with or to be buried in the ground. Steel or galvanized steel is required to be protected by at least double spiral wrapping, half overlapping with 10 mil plastic tape (total 40 mils cover) or approved equal.

Title 10: Subdivisions

Municipal Code Title 10: Subdivisions, identifies the requirements for subdivisions within the City. A property cannot be subdivided unless the subdivider has complied with all provisions of Title 10 and the Map Act. Section 10.55.020, Soils Report, requires submittal of a Preliminary Soils Report and Final Soils Report prepared by a registered civil engineer. Section 10.55.020 details the content of the Preliminary Soils Report and Final Soils Report, as described below.

<u>Preliminary Soils Report</u>. A Preliminary Soils Report, prepared by a registered civil engineer and based upon adequate test borings, is required to be submitted to the City Engineer and Building Official concurrently with improvement plans. The Preliminary Soils Report shall include a

complete description of the site based on a field investigation of soils matters, including stability, erosion, settlement, feasibility of construction of the proposed improvements, description of soils related hazards and problems and proposed methods of eliminating or reducing these hazards and problems.

The investigation and report shall include field investigation and laboratory tests with detailed information and recommendations relative to all aspects of grading, filling and other earthwork, foundation design, pavement design and subsurface drainage.

The report shall also recommend any required corrective action for the purpose of preventing structural damages to the subdivision improvements and the structures to be constructed on the lots. The report shall also recommend any special precautions required for erosion control, and the prevention of sedimentation or damage to off-site property.

If the Preliminary Soils Report indicates the presence of critically expansive soils or other soils problems which, if not corrected, would lead to structural defects, or environmental impacts, the City Engineer and Building Official may require the subdivider to submit a subsequent soils investigation of each parcel in the subdivision prior to approval of a Parcel or Final Map.

<u>Final Soils Report</u>. The subdivider shall submit a Final Soils Report prepared by a registered civil engineer. The Final Soils Report shall contain sufficient information to ensure compliance with all recommendations of the Preliminary Soils Report and the specifications for the project. Additionally, the report shall also contain information relative to soils conditions encountered which differed from that described in the Preliminary Soils Report, along with any corrections, additions, or modifications not shown on the approved plans.

<u>Geologic Investigation and Report</u>. Additionally, if the City Engineer or Building Official determine conditions warrant, a geologic investigation and report may also be required.

5.9.3 IMPACT THRESHOLDS AND SIGNIFICANCE CRITERIA

CEQA SIGNIFICANCE CRITERIA

The environmental analysis in this section is patterned after the Initial Study Checklist recommended by Appendix G of the *CEQA Guidelines*, as amended, and used by the City of Seal Beach in its environmental review process, and is contained in <u>Appendix 11.1</u> of this EIR. The Initial Study Checklist includes questions relating to geology and seismic hazards. The issues presented in the Initial Study Checklist have been utilized as thresholds of significance in this section. Accordingly, a project may create a significant environmental impact if it would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and

Geology Special Publication 42 (refer to Section 8.0, *Effects Found Not To Be Significant*).

- o Strong seismic ground shaking (refer to Impact Statement GEO-1).
- o Seismic-related ground failure, including liquefaction (refer to Impact Statement GEO-2).
- o Landslides (refer to Section 8.0, *Effects Found Not To Be Significant*).

- Result in substantial soil erosion or the loss of topsoil (refer to Impact Statement GEO-3).
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on-or off-site landslide, lateral spreading, subsidence, liquefaction or collapse (refer to Impact Statement GEO-4).
- Be located on expansive soil, as defined in Table 18-1-B of the California Building Code (2004), creating substantial risks to life or property (refer to Impact Statement GEO-5).
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water (refer to Section 8.0, *Effects Found Not To Be Significant*).

Based on these standards, the effects of the proposed project have been categorized as either a "less than significant impact" or a "potentially significant impact." Mitigation measures are recommended for potentially significant impacts. If a potentially significant impact cannot be reduced to a less than significant level through the application of mitigation, it is categorized as a significant unavoidable impact.

5.9.4 IMPACTS AND MITIGATION MEASURES

STRONG SEISMIC GROUND SHAKING

GEO-1 THE PROPOSED PROJECT MAY EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS INVOLVING STRONG SEISMIC GROUND SHAKING.

Impact Analysis: Given the highly seismic character of the southern California region, and proximity to major active faults, severe ground shaking should be expected at the project site. The project would allow for the development of a 48-lot residential development located on approximately 4.5 acres in the northern portion of the project site and open space/passive recreation uses on the remaining approximately 6.4 acres of the project site. As proposed, the project would involve finished pads and all infrastructure necessary to serve the new residential development. The residential units would be developed individually by homeowners as custom homes.

In general, the City regulates development (and reduces potential geologic impacts) under the requirements of the Municipal Code, City land use policies and zoning, as well as project-specific mitigation measures. In accordance with Municipal Code Section 9.60.020, each individual dwelling unit associated with the future residential development would be required to obtain a separate building permit from the building official prior to construction. As part of the plan check process, the City would verify that the proposed structure would be constructed in compliance with all State and City laws and ordinances, including but not limited to, the Building and Safety Code. All structures associated with the future residential development would be required to be designed to withstand the design-level earthquake as set forth in the City's Building and Safety Code. Thus, potential adverse impacts to new structures as a result of strong, seismically-induced, vibratory ground motion would be reduced to a less than significant level with proper seismic design.

Mitigation Measures: No mitigation measures are required.

Level of Significance: Less Than Significant Impact.

OTHER SEISMICALLY INDUCED HAZARDS

GEO-2 THE PROPOSED PROJECT MAY EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS ASSOCIATED WITH SEISMICALLY INDUCED LIQUEFACTION, LATERAL SPREADING, LANDSLIDING, SETTLEMENT, AND/OR GROUND LURCHING.

Impact Analysis: As discussed in the "Existing Setting" discussion above, the following seismically induced hazards have been identified within the project site:

<u>Liquefaction</u>. Saturated paralic soils are subject to varying amounts of liquefaction-induced settlement resulting from strong seismically-induced ground motions. The impacts to structures having footings or structural elements founded in these soils could be significant unless mitigated. Additionally, the susceptibility of paralic soils, as well as non-engineered (i.e., loose) fill soils to seismically-induced settlement presents a significant impact to the project site.

<u>Lateral Spreading</u>. Due to the presence of underlying liquefaction-prone soils and the project site's proximity to the San Gabriel River, there is high potential for seismically-induced lateral spread to occur at the project site. Significant distress to above- and below-ground structures would occur in the event of this form of seismically-induced landsliding. Lateral spread could impact a majority (approximately 80 percent) of the proposed residential area, as well as the southern (approximately 25 percent) and western central portion of the project site. The impact could be significant unless mitigated.

<u>Landsliding</u>. Given the perceived, weak nature of the soils underlying the levee of the San Gabriel River, the levee and portions of the project site along the eastern side of the levee are subject to landsliding during a moderate to strong seismic event in the area. Further, ground lurching may occur where deposits of loose alluvium and/or artificial fill soils exist adjacent to the San Gabriel River levee. The impact could be significant unless mitigated.

<u>Settlement</u>. Holocene-age paralic soils, as well as non-engineered (i.e., loose) fill soils located within the project site, are subject to seismically-induced settlement. The impact could be significant unless mitigated.

<u>Ground Lurching</u>. Ground lurching may occur where deposits of loose alluvium and/or artificial fill soils exist adjacent to the San Gabriel River. The impact could be significant unless mitigated.

The City regulates geotechnical hazards associated with site development through its Municipal Code, including compliance with the CBC. Municipal Code Section 10.55.020, Soils Reports, requires a preliminary soils report concurrent with submittal of the subdivision's improvement plans, prepared by a registered civil engineer and based upon adequate test borings. The preliminary soils report is required to identify hazards and problems related to soils and include methods of eliminating or reducing the hazards or problems. The preliminary soils report is also required to include a field investigation and laboratory tests for grading and design recommendations, including corrective actions to prevent structural damages. In compliance with Municipal Code Section 10.55.020, the Preliminary Geotechnical Evaluation and Geology Report have been prepared to identify existing soils and geotechnical conditions that occur within the project site, including preliminary recommendations pertaining to design and construction. The Preliminary Geotechnical Evaluation and Geology Report provide recommendations regarding earthwork, foundation support, concrete construction, retaining wall design and construction, and post construction guidelines, among other recommendations, that would be required to be incorporated into the design and construction phases of the proposed project.

According to Municipal Code Section 10.55.020, if the preliminary soils report indicates the presence of critically expansive soils or other soil problems that could potentially lead to structural defects if not corrected, the City Engineer or Building Official may require the subdivider to submit a subsequent soils investigation of each parcel in the subdivision prior to approval of Final Tract Map. Municipal Code Section 10.55.020 also requires submittal of a final soils report to ensure compliance with the recommendations of the preliminary soils report and specifications for the project, and to provide information relative to soils conditions that may differ from those described in the preliminary soils reports, along with any corrections, additions, or modifications not shown on the approved plans. As concluded in the Preliminary Geotechnical Evaluation and Geology Report, soil conditions exist that could potentially lead to structural defects if not corrected. Therefore, as part of the Final Tract Map, a Final Soils/Geotechnical Engineering Report would be required to ensure compliance with the recommendations of the Preliminary Geotechnical Evaluation and Geology Report and any recommendations identified by the City's Engineer (Mitigation Measure GEO-1). In addition, the Final Grading Plan for Tentative Tract Map No. 17425 and building and engineering plans for the future residential developments would be required to incorporate all engineering recommendations within the Final Soils/Geotechnical Engineering Report (Mitigation Measures GEO-2 and GEO-3). With implementation of Mitigation Measure GEO-1, GEO-2, and GEO-3, potential impacts associated with seismically induced hazards would be reduced to a less than significant level.

Mitigation Measures:

GEO-1 Prior to issuance of any grading permit, the project applicant shall prepare a Final Soils/Geotechnical Engineering Report for review and approval by the City's Engineer. The Final Soils Geotechnical Engineering Report shall be prepared by a professional engineer and certified engineering geologist licensed by the State of California, in consultation with a corrosion engineer, and demonstrate compliance with the following recommendations identified in the *Preliminary Geotechnical Evaluation for Proposed Residential Development*, prepared by GeoTek, Inc., dated September 12, 2005, and the *Geology, Soils, and Seismicity Report in Support of DWP Specific Plan Amendment EIR, Seal Beach California*, prepared by D. Scott Magorien, C.E.G. Consulting Engineering Geologist, dated June 27, 2011, and any additional recommendations identified by the City's Engineer. The Preliminary Geotechnical Evaluation and Geology Report are included in Appendix 11.8, *Geology, Soils, and Seismicity Data* of this EIR and are incorporated by reference into this mitigation measure. The following recommendations shall be addressed and incorporated into the Final Soils Geotechnical Engineering Report:

Earthwork Considerations

Earthwork and grading shall be performed in accordance with the applicable grading ordinances of the current California Building Code (CBC), and the following recommendations. The Grading Guidelines included in Appendix D of the *Preliminary Geotechnical Evaluation for Proposed Residential Development*, prepared by GeoTek, Inc., dated September 12, 2005 outline general procedures and do not anticipate all site-specific situations. In the event of conflict, the following recommendations shall supersede those contained in Appendix D of the *Preliminary Geotechnical Evaluation for Proposed Residential Development.*

- Site Clearing. In areas of planned grading or improvements, the site shall be cleared of vegetation, roots, and debris, and properly disposed of offsite. Any holes resulting from site clearing, tree removal, and/or the backhoe trenches excavated shall be replaced with properly compacted fill materials.

- Fills. Any import fill shall consist of relatively low-expansive soils (EI<50) and shall be evaluated by a Registered Civil Engineer/Geotechnical Engineer, approved by the City, prior to arrival at the project site. The fill materials shall be compacted in layers no thicker than 8 inches to at least 90 percent of maximum dry density with a moisture content of at least optimum, as determined in accordance with American Society for Testing and Materials (ASTM) Test Method D1557-00. Those areas to receive fill shall be scarified to a depth of 8 inches; moisture conditioned to at least optimum moisture content and recompacted to at least 90 percent of maximum dry density.

- Removals. Existing fill materials shall be subject to complete removal and recompaction within the limits of grading. In those areas where the depth of existing fill materials extends below the groundwater table, the upper eight to 10 feet of soil, along with organic and other deleterious materials, shall be removed. If saturated and yielding subgrade conditions are encountered upon removal of the upper soils within those areas exhibiting a shallow ground water surface, the contractor shall place uniform sized, ¾- inch crushed rock within the area exhibiting the "pumping" conditions. The crushed rock shall be properly tracked into the underlying soils such that it is adequately intruded into and interlocks with the soils. The necessary thickness of the crushed rock shall be evaluated during construction. Following the placement and tracking of the gravel layer into the underlying "pumping" soils, Mirafi 600X stabilization fabric (or approved equivalent) shall be placed upon the gravel layer. Fill soils shall then be placed upon the fabric and compacted to a minimum 90 percent relative compaction (based on ASTM test method D1557) until finished grades are reached. The gravel and stabilization fabric shall extend at least 5 feet laterally beyond the limits of the "pumping" areas. These operations shall be performed under the observation and testing of a professional engineer or a certified engineering geologist licensed by the State of California, approved by the City in order to evaluate the effectiveness of these measures and to provide additional recommendations, as warranted.

Following the completion of rough grading at the site, settlement monuments shall be installed at finish rough grade. These monuments shall be established based on a known bench mark and their elevations shall be monitored by a licensed land surveyor on a weekly basis. The surveyor's settlement monument data shall be reviewed weekly by the Registered Civil Engineer/Geotechnical Engineer, approved by the City. This monitoring shall continue until the consolidation is deemed to have sufficiently stabilized. Once it has been concluded that the remaining settlement is within acceptable levels, the settlement monuments may be destroyed and fine grading may proceed.

- <u>Excavation Characteristics</u>. All temporary excavations for grading purposes and installation of underground utilities shall be constructed in accordance with Occupational Safety and Health Administration (OSHA) guidelines.

- <u>Expansive Soils</u>. Placement of any clayey soils within three feet of finish grades shall be avoided.

<u>Foundation Support</u>

- <u>Conventional Foundation Recommendations</u>. In the areas where complete removal and recompaction of the upper soils can be accomplished, the proposed residential structures shall be supported on conventional continuous or isolated spread footings bearing entirely upon properly compacted fill materials. Foundations supporting single story structures shall be constructed with an embedment of at least 12 inches below finish grade, while those supporting two-story structures shall be constructed with an embedment of at least 18 inches below finish grade. At these depths, footings shall be designed for an allowable soil bearing value of 2,000 pounds per square foot (psf). This value shall be increased by one-third for loads of short duration, such as wind and seismic forces. Continuous footings supporting single-story structures shall have a minimum width of 12 inches, while those supporting two-story structures shall have a minimum width of 15 inches. Based on geotechnical considerations, footings shall be provided with reinforcement consisting of two No. 4 rebars, one top and one bottom. A minimum width of 24 inches for isolated spread footings shall be provided. Passive resistance to lateral loads shall be computed as an equivalent fluid pressure having a density of 250 psf per foot of depth to a maximum earth pressure of 3,000 psf. A coefficient of friction between soil and concrete of 0.30 shall be used with dead load forces. When combining passive and frictional resistance, the passive pressure component shall be reduced by one-third.

- Special Foundation Systems. In the areas where incomplete removals are performed and/or the potential for seismically induced differential settlement exists, special foundation systems such as mat foundations, post-tensioned slabs, or drilled pier foundation systems shall be considered for support of the proposed residential structures.

  If mat foundations are used to support the proposed residential structures, the mat foundations shall be designed to bridge over voids that may develop under the slab due to differential settlement. The mat foundation shall be founded within compacted fill materials, with a minimum embedment of 18 inches below finish grade. For mats founded on soft, wet, or cohesionless soils, special preparation of the bottom shall be required to support construction traffic.

  Mat foundations shall be properly reinforced to form a relatively rigid structural unit in accordance with the structural engineers design. For preliminary design purposes, an uncorrected modulus of subgrade reaction of 100 pounds per cubic inch (pci) shall be assumed. For large foundations, the modulus shall be reduced by 75 percent (i.e., to 25 pci). Actual geotechnical design parameters shall be provided upon completion of a more complete geotechnical evaluation of the proposed building site.

  If post-tensioned slabs are used to support the proposed residential structures, the structural design of post-tensioned slabs shall follow the recommendations of the Post-Tensioning Institute (PTI) Method and Section 1819 of the 2001 California Building Code (i.e., 1808 [Foundations] and 1808.6.2 [Slab on Ground Foundations]).

  Based on the geotechnical data acquired during the subsurface exploration, an allowable bearing capacity of 1,500 psf, and a slab-subgrade friction coefficient of 0.75 shall be used for design of post-tensioned slabs. Final design shall be verified based upon actual soil conditions encountered and results of laboratory testing performed during or at the completion of site grading.

  If drilled piers are used to support the proposed residential structures, the drilled piers shall be designed utilizing either end-bearing or skin friction design. Drilled piers shall be embedded at least 5 feet within the alluvial materials or 14 feet below the existing ground surface (whichever is deeper). Design of drilled piers subjected to earthquake loading shall consider the effects of downdrag, due to the potential for liquefaction within portions of the fill.

  Because of the relatively high ground water level, along with the presence of poorly graded sands within the fill and alluvium, temporary casing or bentonite slurry shall be utilized to support the walls of the shaft prior to the placement of concrete. Further, the cleaning of loose slough from the bottom of the shaft excavation shall be warranted for drilled piers that will derive their support from end-bearing conditions.

- Seismic Design Parameters. Seismically resistant structural design in accordance with local building ordinances shall be followed during the design of all structures. For the purpose of seismic design, a Type B seismic source (L.A. Basin segment of the Newport-Inglewood Fault) located less than 2 kilometers from the site shall be used.

- Foundation Setbacks. Where applicable, the following setbacks shall apply to all foundations:

  - The outside bottom edge of all footings shall be set back a minimum of HI3 (where H is the slope height) from the face of any descending slope. The setback shall be at least seven feet and need not exceed 20 feet.

  - The bottom of all footings for structures near retaining walls shall be deepened so as to extend below a 1:1 projection upward from the bottom inside edge of the wall stem.

  - The bottom of any existing foundations for structures shall be deepened so as to extend below a 1:1 projection upward from the bottom of the nearest excavation.

- Slab-On-Grade. Where applicable, concrete slabs (including the mat foundations recommended above) shall be a minimum of four inches thick and reinforced as per structural engineer requirements. Control joints shall be provided to help reduce random cracking. Slabs shall be underlain by a four inch thick capillary break layer consisting of clean sand (S.E. of 30 or greater). Where moisture condensation is undesirable, all slabs shall be underlain with a minimum six mil polyvinyl chloride membrane, sandwiched between two layers of clean sand (S.E. 30 or greater), each being at least two inches thick. Care shall be taken to adequately seal all seams and not puncture or tear the membrane. The sand shall be proof rolled. This recommendation is based on soil support characteristics only. The structural engineer shall design the actual slab and beam reinforcement based on expansion indices of the finish grade soils, actual loading conditions, and possible concrete shrinkage.

- Soil Corrosivity. A corrosion engineer shall be consulted to provide recommendations for proper protection of buried metal pipes at this site.

- Utilities. Due to the project site's susceptibility to liquefaction and a considerable amount of seismically-induced settlement and lateral spreading, consideration shall be given to "flexible" design for on-site utility lines and connections. Except where extending perpendicular to/under proposed foundations, utility trenches shall be constructed outside a 1:1 projection from the base-of-foundations. Trench excavations for utility lines which extend under structural areas shall be properly backfilled and compacted. Utilities shall be bedded and backfilled with clean sand or approved granular soil to a depth of at least one foot over the pipe. This backfill shall be uniformly watered and compacted to a firm condition for pipe support. The remainder of the backfill shall be typical on-site soil or imported soil which shall be placed in lifts not exceeding eight inches in thickness, watered or aerated to 0 to 3 percent above the optimum moisture content, and mechanically compacted to at least 90 percent of maximum dry density (based on ASTM D1557).

Concrete Construction

Concrete construction shall follow the California Building Code and American Concrete Institute guidelines regarding design, mix placement and curing of the concrete.

- Cement Type. Type I1 cement or an equivalent shall be used in those concrete elements that will be in contact with the upper soils.

- Control Flatwork. Control joints shall be provided in accordance with American Concrete Institute Guidelines to control cracking of exterior concrete flatwork (patios, walkways, driveways, etc.). Other methods to control cracking shall include careful control of water/cement ratios in the concrete, along with taking appropriate curing precautions during the placement of concrete in hot or windy weather.

Retaining Wall Design and Construction

Recommendations presented herein apply to typical masonry or concrete vertical retaining walls to a maximum height of 10 feet. Additional review and recommendations shall be required for higher walls. Foundations for retaining walls embedded a minimum of 18 inches into compacted fill shall be designed using a net allowable bearing capacity of 2,000 psf. An increase of one-third shall be applied when considering short-term live loads (e.g., seismic and wind loads). The passive earth pressure shall be computed as an equivalent fluid having a density of 250 psf per foot of depth, to a maximum earth pressure of 3,000 psf. A coefficient of friction between soil and concrete of 0.30 shall be used with dead load forces. When combining passive pressure and frictional resistance, the passive pressure component shall be reduced by one-third. An equivalent fluid pressure approach shall be used to compute the horizontal active pressure against the wall. The appropriate fluid unit weights are provided below for specific slope gradients of retained materials.

Surface Slope of Retained Materials (H:V)	Equivalent Fluid Pressure (PCF)
Level	35
2:1	55

The above equivalent fluid weights do not include other superimposed loading conditions such as expansive soil, vehicular traffic, structures, seismic conditions or adverse geologic conditions.

- Wall Backfill and Drainage. The onsite sandy materials possessing a low expansion potential that are used for backfill shall be screened of greater than three inch size gravels. If other materials are present the parameters provided shall be reviewed and if necessary, modification to the wall designs shall be made. The backfill materials shall be placed in lifts no greater than eight inches in thickness and compacted at 90 percent relative compaction in accordance with ASTM Test Method D1557-00. Proper surface drainage shall be provided and maintained.

  Retaining walls shall be provided with an adequate pipe and gravel back drain system to prevent build up of hydrostatic pressures. Backdrains shall consist of a 4-inch diameter perforated PVC pipe embedded in a minimum of one cubic foot per lineal foot of 3/8 to one inch clean crushed rock or equivalent, wrapped in filter fabric (Mirafi 140N or an approved equivalent). The drain system shall be connected to a suitable outlet. A minimum of two outlets shall be provided for each drain section.

  Walls from two to four feet in height shall be drained using localized gravel packs behind weep holes at 10 feet maximum spacing (e.g., approximately 1.5 cubic feet of gravel in a woven plastic bag). Weep holes shall be provided or the head joints omitted in the first course of block extended above the ground surface.

Post Construction

- Landscape Maintenance and Planting. Positive surface drainage away from graded slopes shall be maintained and only the amount of irrigation necessary to sustain plant life shall be provided for planted slopes. Plants selected for landscaping shall be lightweight, deep-rooted types that require little water and are capable of surviving the prevailing climate.

  Over watering shall be avoided. The soils shall be maintained in a solid to semi-solid state as defined by the materials' Atterberg Limits. Care shall be taken when adding soil amendments to avoid excessive watering. Leaching as a method of soil preparation prior to planting shall not occur.

  Planting placed adjacent to structures in planter or lawn areas shall be avoided. If used, waterproofing of the foundation and/or subdrains shall occur.

- Drainage. Positive site drainage shall be maintained at all times. Drainage shall not flow uncontrolled down any descending slope. Water shall be directed away from foundations and not allowed to pond or seep into the ground. Pad drainage shall be directed toward approved area(s). Positive drainage shall not be blocked by other improvements.

  A de-watering system shall be implemented if below-grade construction (i.e., basements, etc.) is planned to extend down to or below depths of between nine and 15 feet below existing site grades.

Implementation and operation (as deemed necessary) of de-watering procedures/equipment both during subterranean construction (if planned) and throughout the lifetime of the structure(s) shall occur. A contractor specializing in the design and implementation of de-watering systems shall be consulted prior to the beginning of construction activities.

Plan Review and Construction Observations

Site grading, specifications, and foundation plans shall be reviewed by a Geotechnical Engineer, approved by the City, prior to construction to verify conformance with the above recommendations. It is recommended that a Geotechnical Engineer be present during site grading and foundation construction to check for proper implementation of the geotechnical recommendations. The Geotechnical Engineer shall perform at least the following duties:

- Observe site clearing and grubbing operations for proper removal of all unsuitable materials.
- Observe and test bottom of removals prior to fill placement.
- Evaluate the suitability of onsite and import materials for fill placement, and collect soil samples for laboratory testing where necessary.
- Observe the fill for uniformity during placement including utility trenches. Also, test the fill for field density and relative compaction.
- Observe and probe foundation materials to confirm suitability of bearing materials and proper footing dimensions.

GEO-2 Prior to issuance of any grading permit, the Grading Plan shall incorporate all engineering recommendations contained within the Final Soils/Geotechnical Engineering Report for the proposed project during project site design and construction, in order to reduce any potential soil and geotechnical hazards at the project site. These recommendations shall be stipulated in the construction contracts and specifications.

GEO-3 Prior to issuance of any building permit for development of each residential lot, the building and engineering plans shall incorporate all engineering recommendations contained within the Final Soils/Geotechnical Engineering Report for the proposed project during lot site design and construction, in order to reduce any potential soil and geotechnical hazards at the residential lots. These recommendations shall be stipulated in the building and engineering plans and specifications.

Level of Significance: Less Than Significant With Mitigation Incorporated.

SOIL EROSION

GEO-3 THE PROPOSED PROJECT MAY RESULT IN SUBSTANTIAL SOIL EROSION OR THE LOSS OF TOPSOIL.

Impact Analysis: The project site primarily consists of pervious surfaces (vacant disturbed land). The short-term effects of soil erosion during rough grading for Tentative Tract Map No. 17425 are not considered significant, given that the project site is essentially flat, and does not possess site conditions necessarily conducive to soil erosion. The project would also be required to comply with all requirements set forth in the NPDES permit for construction activities, as enforced by the Santa Ana Regional Water Quality Control Board. Additionally, erosion and loss of topsoil as a result of wind (fugitive dust) would be minimized with implementation of Mitigation Measure AQ-1. With implementation of Mitigation Measures AQ-1 and compliance with NPDES requirements, erosion is not expected to be a significant impact to development and impacts would be less than significant.

Long-term soil erosion can be caused by a number of factors, such as rising sea levels, reduced sediment supply to the coast, dredging of the nearby San Gabriel River, and increased incidence of intensity of storms. However, given the inherent uncertainties regarding long-term shoreline erosion, impacts on soil erosion within the project area cannot be fully assessed. According to the Geologic Report, the project as proposed is not anticipated to result in significant impacts associated with long-term shoreline erosion.

Mitigation Measures: No mitigation measures are required.

Level of Significance: Less Than Significant Impact.

UNSTABLE GEOLOGIC UNITS

GEO-4 DEVELOPMENT OF THE PROPOSED PROJECT COULD BE LOCATED ON A GEOLOGIC UNIT OR SOIL THAT IS UNSTABLE, OR THAT WOULD BECOME UNSTABLE AS A RESULT OF THE PROJECT.

Impact Analysis: The project site is relatively flat and there are no documented landslides within or adjacent to the project area. Further, there is no current evidence that suggests the presence of collapsible soils on the project site. Refer to Impact Statement GEO-2 regarding seismically-induced hazards including landsliding, lateral spreading, and liquefaction.

<u>Subsidence</u>

There is no indication that the project site has experienced any significant subsidence or rebound since 1970. Further, there has been no measurable land subsidence documented within the nearby Seal Beach/Hellman Ranch oil field during the last 60 years. Potential subsidence impacts would be less than significant.

<u>Shallow Groundwater</u>

Saturated soils and caving conditions would likely be encountered during remedial grading associated with removal and re-compaction of soils within several feet above, or at any depth below the groundwater table. Depending upon the construction methods employed, dewatering may be required in order to safely excavate the project site just above and below groundwater, which would likely require some form of lateral support. Compliance with Mitigation Measures GEO-1 and GEO-2 would ensure that potential impacts associated with shallow groundwater would be reduced to a less than significant level. Further, the saline groundwater pumped from the dewatering wells would be required to meet National Pollutant Discharge Elimination System (NPDES) permit requirements prior to discharge; refer to Section 5.11, *Hydrology and Water Quality*.

Sloughing or Caving of Excavations

During construction of the proposed project, excavations associated with remedial grading/ground stabilization and underground utilities would encounter unconsolidated/noncohesive artificial fill, as well as saturated paralic soils. If unsupported, these soils would be subject to sloughing and caving, creating a short-term hazard to construction workers and equipment. Compliance with Mitigation Measures GEO-1 and GEO-2 would ensure that potential impacts associated with sloughing or caving of excavations would be reduced to a less than significant level.

Mitigation Measures: Refer to Mitigation Measures GEO-1 and GEO-2.

Level of Significance: Less Than Significant With Mitigation Incorporated.

EXPANSIVE SOILS

GEO-5 THE PROPOSED PROJECT MAY BE LOCATED ON EXPANSIVE SOIL CREATING SUBSTANTIAL RISKS TO LIFE OR PROPERTY.

Impact Analysis: The laboratory tests performed for the project site indicate that the soils encountered are anticipated to exhibit "low to medium" expansion potential. The potential for expansive soils to impact new development is considered low. The Preliminary Geotechnical Evaluation recommends that placement of any clayey (expansive) soils imported to the project site be avoided within three feet of finish grades. Compliance with Mitigation Measures GEO-1 and GEO-2 would ensure that potential impacts associated with expansive soils imported to the project site would be reduced to a less than significant level.

Mitigation Measures: Refer to Mitigation Measures GEO-1 and GEO-2.

Level of Significance: Less Than Significant With Mitigation Incorporated.

CORROSIVE SOILS

GEO-6 DEVELOPMENT OF THE PROPOSED PROJECT COULD ENCOUNTER CORROSIVE SOILS POTENTIALLY RESULTING IN DAMAGE TO FOUNDATIONS AND BURIED PIPELINES.

Impact Analysis: Corrosive soils contain chemical constituents that can react with construction materials, such as concrete and ferrous metals, that may cause damage to foundations and buried pipelines. According to the Preliminary Geotechnical Report and Geology Report, near surface soils within the project site are considered highly corrosive to ferrous metals in contact with these soils.

Building Code Subsection 313.13 requires steel or galvanized steel to be protected by at least double spiral wrapping, half overlapping with 10 mil plastic tape (total 40 mils cover) or approved equal. The Preliminary Geotechnical Report also recommends, at a minimum, that buried metal piping be protected with suitable coatings, wrapping, or seals. Mitigation Measure GEO-1 requires a corrosion engineer to be consulted during preparation of the Final Soils/Geotechnical Engineering Report. Compliance with the Building Code and Mitigation Measure GEO-1 would reduce potential impacts associated with corrosive soils to a less than significant level.

Mitigation Measures: Refer to Mitigation Measure GEO-1.

Level of Significance: Less Than Significant With Mitigation Incorporated.

5.9.5 CUMULATIVE IMPACTS

STRONG SEISMIC GROUND SHAKING

- **THE PROPOSED PROJECT, COMBINED WITH OTHER RELATED CUMULATIVE PROJECTS, MAY EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS INVOLVING STRONG SEISMIC GROUND SHAKING.**

Impact Analysis: Due to the location and proximity of the project and cumulative projects sites, it is anticipated that the project site and cumulative projects sites would generally experience similar ground shaking associated with seismic activity. However, development of the proposed project and cumulative projects would be required to comply with the CBC in order to reduce potential impacts associated with strong seismic ground shaking to a less than significant level. Therefore, the project would not contribute to cumulative impacts and impacts in this regard are not cumulatively considerable.

Mitigation Measures: No mitigation measures are required.

Level of Significance: Less Than Significant Impact.

OTHER SEISMICALLY INDUCED HAZARDS, UNSTABLE GEOLOGIC UNITS, EXPANSIVE SOILS, AND CORROSIVE SOILS

- **THE PROPOSED PROJECT, COMBINED WITH OTHER RELATED CUMULATIVE PROJECTS, MAY EXPOSE PEOPLE OR STRUCTURES TO POTENTIAL SUBSTANTIAL ADVERSE EFFECTS ASSOCIATED WITH SEISMICALLY INDUCED LIQUEFACTION, LATERAL SPREADING, LANDSLIDING, SETTLEMENT, AND/OR GROUND LURCHING.**

- **THE PROPOSED PROJECT, AND OTHER RELATED CUMULATIVE PROJECTS, COULD BE LOCATED ON A GEOLOGIC UNIT OR SOIL THAT IS UNSTABLE, OR THAT WOULD BECOME UNSTABLE AS A RESULT OF THE PROJECT.**

- **THE PROPOSED PROJECT, AND OTHER RELATED CUMULATIVE PROJECTS, COULD BE LOCATED ON EXPANSIVE SOIL CREATING SUBSTANTIAL RISKS TO LIFE OR PROPERTY.**

- **THE PROPOSED PROJECT, AND OTHER RELATED CUMULATIVE PROJECTS, COULD ENCOUNTER CORROSIVE SOILS POTENTIALLY RESULTING IN DAMAGE TO FOUNDATIONS AND BURIED PIPELINES.**

Impact Analysis: The potential for expansive soils to impact new development at the project site is considered low. However, the project site is subject to seismically induced hazards, unstable geologic units, and corrosive soils. None of the cumulative projects are located adjacent to the project site. The geotechnical characteristics of each cumulative project site would be evaluated on a project-by-project basis, and appropriate mitigation measures would be required, as necessary to reduce potential impacts to a less than significant level. Further, all development within the City would be required to comply with the Building Code, which addresses corrosive soils.

The proposed project would be required to conform to applicable City criteria, adhere to standard engineering practices, and incorporate standard practices of the CBC. Additionally, Mitigation Measures GEO-1, GEO-2, and GEO-3 would require the project to incorporate all engineering recommendations contained within the Preliminary Geotechnical Evaluation and Geology Report and Final Soils/Geotechnical Engineering Report to reduce impacts associated with seismically induced hazards, unstable geologic units, and corrosive soils. Therefore, the project would not contribute to cumulative impacts and impacts in this regard are not cumulatively considerable.

Mitigation Measures: Refer to Mitigation Measures GEO-1, GEO-2, and GEO-3.

Level of Significance: Less Than Significant With Mitigation Incorporated.

SOILS EROSION

- **THE PROPOSED PROJECT, COMBINED WITH OTHER RELATED CUMULATIVE PROJECTS, MAY RESULT IN SUBSTANTIAL SOIL EROSION OR THE LOSS OF TOPSOIL.**

Impact Analysis: Portions of the City and surrounding areas may contain soils that have erosion potential. Construction of planned and future cumulative projects could facilitate soil erosion and loss of topsoil. Grading activities leave soils exposed to rainfall and wind conditions that result in erosion. The geotechnical characteristics of each cumulative project site would be evaluated on a project-by-project basis, and appropriate mitigation measures would be required, as necessary, in addition to Federal and State requirements for mitigating erosion. Therefore, assuming cumulative projects implement project specific mitigation measures, cumulative soil erosion and loss of topsoil impacts would be less than significant.

The short-term effects of soil erosion during rough grading for Tentative Tract Map No. 17425 are not considered significant, given that the project site is essentially flat, and does not possess site conditions necessarily conducive to soil erosion. The project would be required to comply with all requirements set forth in the NPDES permit for construction activities, as enforced by the Santa Ana RWQCB. Additionally, erosion and loss of topsoil as a result of wind (fugitive dust) would be minimized with implementation of Mitigation Measure AQ-1. Thus, the project would not contribute to cumulative impacts and impacts in this regard are not cumulatively considerable.

Mitigation Measures: No mitigation measures are required.

Level of Significance: Less Than Significant Impact.

5.9.6 SIGNIFICANT UNAVOIDABLE IMPACTS

No significant impacts related to Geology and Soils have been identified following implementation of the recommended Mitigation Measures GEO-1 through GEO-3 and compliance with the applicable Federal, State, and local regulatory requirements.